

Bonner zoologische Beiträge	Band 56 (2007)	Heft 1/2	Seiten 107–129	Bonn, März 2009
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Islands Between the Realms: A Revised Checklist of the Herpetofauna of the Talaud Archipelago, Indonesia, with a Discussion About its Biogeographic Affinities

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Abstract. Since the last taxonomic account was published 80 years ago, we provide the first updated annotated checklist for the herpetofauna of the remote Talaud Archipelago, which lies between the biogeographic realms of Sulawesi, the Philippines, and the Moluccas. We report on a small collection from Pulau (= island) Salibabu, the second largest island within the Talaud Archipelago, which, until recently, was one of the least-known areas of the Sulawesi region. In total, 37 specimens representing three anuran species, 11 lizard species (four geckos, four skinks, two agamids, and one monitor lizard species), and two snake species were collected. Of these, six species, viz. one microhylid frog (*Callulops* cf. *dubius*), three lizard species (*Nactus* cf. *pelagicus*, *Gehyra mutilata*, and *Eutropis* cf. *rudis*), and two snake species (*Typhlops* sp. and *Boiga irregularis*), are recorded here for the first time for the Talaud Islands, while *Hydrosaurus* sp., *Cyrtodactylus* cf. *jellesmae*, *Eutropis multicarinata* and *Emoia atrocostata* have not been previously known from Salibabu Island. Novel records for Talaud are completed by *Hemidactylus frenatus* and *Eutropis multifasciata* from the MCZ online database. A historical record of *Gekko vittatus* may be incorrect but seems possible given the biogeographic distribution patterns of Australopapuan amphibian and reptile species discussed in this paper. Historical reports of *Candoia* reaching North Sulawesi appear dubious. Combined with previous records, the herpetofauna of Talaud currently comprises 27 species of amphibians and reptiles that include three different species of frogs, 17 lizards (five geckos, eight skinks, three agamids, and one varanid), five snake species as well as one sea turtle and one crocodile. Two historical records of *Gekko vittatus* and *Bronchocelea jubata*, respectively, require verification.

Finally, the zoogeographic affinities of the Talaud Islands and their implications for the course of past dispersal routes between the Philippines, North Sulawesi and the northern Moluccas are discussed in the light of herpetofaunistic distribution patterns compared with those shown by other groups of organisms.

Keywords. Wallacea, Sulawesi region, amphibians, reptiles, biogeography, endemism.

Abstrak (Bahasa Indonesia). Kami memperbaharui daftar jenis-jenis herpetofauna yang ditemukan di Kepulauan Talaud, yang secara biogeografi diapit oleh Sulawesi, Kepulauan Filipina, dan Kepulauan Maluku, setelah daftar yang pertama dipublikasikan 80 tahun yang lalu. Laporan kami mencakup koleksi amfibi dan reptil yang berasal dari Pulau Salibabu, yang merupakan pulau terbesar kedua di Kepulauan Talaud yang sampai saat ini kurang dikenal dibandingkan dengan daerah lain di sekitar Sulawesi. Di antara koleksi kami yang berjumlah total 37 spesimen, termasuk di dalamnya adalah 3 jenis amfibi dari kelompok Anura, 4 jenis Cicak, 4 jenis Kadal, 2 jenis Londok, dan 1 jenis Biawak. Enam (6) jenis di antara koleksi kami ini baru pertama kalinya dilaporkan dari Kepulauan Talaud, yaitu 1 jenis katak Mikrohila (*Callulops* cf. *dubius*), 2 jenis Cicak (*Nactus* cf. *pelagicus* dan *Gehyra mutilata*), 1 jenis Kadal (*Eutropis* cf. *rudis*), dan 2 jenis Ular (*Typhlops* sp. dan *Boiga irregularis*). Catatan baru dari Pulau Salibabu adalah *Hydrosaurus* sp., *Cyrtodactylus* cf. *jellesmae*, *Eutropis multicarinata* and *Emoia atrocostata*. Kami juga menambahkan *Hemidactylus frenatus* dan *Eutropis multifasciata* ke dalam daftar kami, karena kedua jenis ini dilaporkan telah ditemukan di Kepulauan Talaud dalam daftar online MCZ. Laporan mengenai *Gekko vittatus* yang berasal dari Kepulauan Talaud kemungkinan kurang tepat, namun dapat dibenarkan bila didasarkan pada pola persebaran biografi amfibi dan reptil di daerah Australopapua yang kami ulas dalam tulisan ini. Selanjutnya, laporan tentang ditemukannya *Candoia* di bagian utara Sulawesi kurang dapat dibenarkan. Sampai saat ini, secara keseluruhan tercatat 27 jenis amfibi dan reptil dari Kepulauan Talaud, yang mencakup 3 jenis Katak, 5 jenis Cicak, 8 jenis Kadal, 3 jenis Londok, satu jenis Biawak, dan 5 jenis Ular, di samping 1 jenis Penyu dan 1 jenis Buaya. Seluruh catatan mengenai hewan-hewan ini kami susun dalam sebuah daftar beserta keterangan tambahannya.

Kami juga memaparkan keterlibatan Kepulauan Talaud dalam jalur persebaran amfibi dan reptil yang telah terjadi di antara Pulau Sulawesi, Kepulauan Filipina, dan Kepulauan Maluku dan membandingkannya dengan jalur persebaran organisme lain di daerah ini.

Kata kunci. Wallacea, Sulawesi, amfibia, reptilia, biogeografi, jenis endemik.

1. INTRODUCTION

The Talaud Archipelago represents the northern most area within the Wallacea transition zone between the Oriental and Australian faunal regions. The remote island group lies in the northern Molucca Sea between North Sulawesi, Mindanao in the southern Philippines, and Halmahera in the northern Moluccas. The Talaud Archipelago comprises three main islands: Karakelong, Salibabu and Kaburuang (Fig. 1). Geologically, the Molucca Sea Plate with its inverted U-shape dips east under Halmahera and west under the Sangihe Arc (MCCAFFREY et al. 1980). The Talaud Islands are situated on the Sangihe forearc separated by a deep ocean trench from the largely submarine Sangihe Arc with its few emergent volcanic islands like Sangihe and Siau (HALL 2002). The Talaud Island group consists of a sedimentary sequence of Middle Miocene to Pleistocene age and includes probable mid-Miocene volcanic rocks and volcanoclastic turbidites (MOORE et al. 1981). Pleistocene coral limestone, the youngest rocks on Talaud, are exposed mostly along the coast lines (Fig. 2), but al-

so at 400–500 m elevation on Kaburuang, showing the significant amount of recent uplift (MOORE et al. 1981). The highest elevation of only 650 m above sea level is found on Karakelong Island.

The Talaud Islands together with Sulawesi and other islands of present day central Indonesia belong to a biogeographic transition region called Wallacea (see summaries by MAYR [1944] and SIMPSON [1977]). Australopapuan and Asian animals meet at the respective outer limits of their distribution. Consequently, in the light of biogeography, the Talaud Islands form the northernmost submerged area of this region. Traditionally, the Talaud Archipelago has been dealt with scientifically with Sulawesi to which it is indirectly connected via the Sangihe Island arch. However, the direct over-water distance to North Sulawesi of about 300 km is significantly more distant than Halmahera in the Moluccas (ca. 210 km) or Mindanao in the Philippines (ca. 170 km).

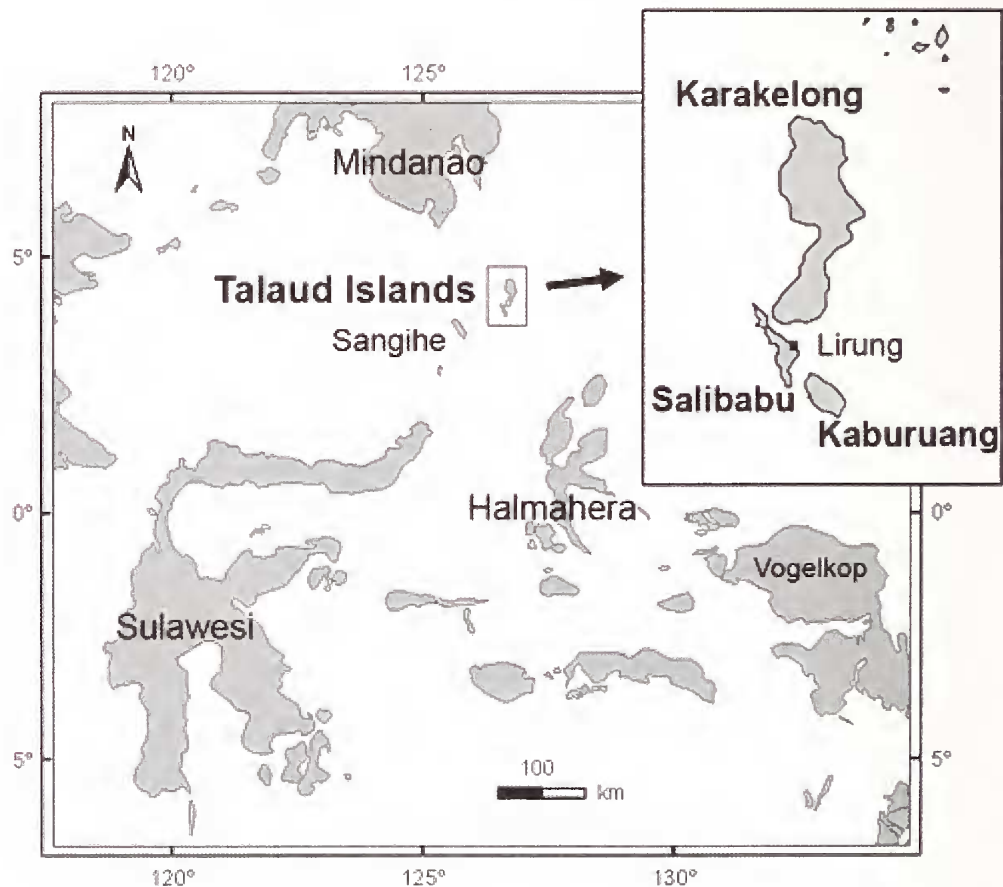


Fig. 1. Map of the Talaud Islands located between Sulawesi, Halmahera (Moluccas) and Mindanao (Philippines).



Fig. 2. Coast line with coral limestone deposits on Salibabu Island. Habitat of *Varanus* sp. and *Emoia a. atrocostata*. Photo by André Koch.

The geographically isolated position between three biogeographic subregions in the centre of the Indo-Australian Archipelago render the Talaud Islands an interesting field of research for biogeographers. Until recently, however, the Talaud Archipelago (together with Sangihe) has been one of the least-known areas of the Sulawesi region as defined by VANE-WRIGHT (1991). Hence, due to their minor geographic size together with their remote location, the Talaud Island group has been paid only little attention by herpetologists in the past and scientific literature about the herpetofauna of this small archipelago is scarce. VAN KAMPEN (1907; 1923) and DE ROOIJ (1915; 1917) provided the first herpetological data about the Talaud Islands based on material collected by M. WEBER during the Siboga Expedition of 1899. DE ROOIJ (1915; 1917) listed five different lizard species (*Calotes jubatus*, *Varanus indicus*, *Lygosoma cyanurum*, *Lygosoma rufescens*, and *Mabuia multicarinata*) and one snake species (*Candoia carinata*). Later, DE JONG (1928) published the results of another small collection by the Dutch botanist H. J. LAM who visited Karakelong and Salibabu as well as Miangas, a small islet south of Mindanao, in 1926 (LAM 1926; 1942). His Talaud collection comprised ten different species representing eight lizards and two snakes. Voucher specimens by M. WEBER and H. J. LAM from the Ta-

laud Islands are mostly deposited in the Zoological Museum of the University of Amsterdam. A few of their specimens are stored in the herpetological collection of the Museum Zoologicum Bogoriense (MZB) on Java. Further material (e. g., collected by the Snellius Expedition in 1930) are located in the collections of the Natural History Museum Naturalis in Leiden (RMNH), the Netherlands.

The herpetology department of the Museum of Comparative Zoology (MCZ), Harvard University, houses a small number of vouchers (MCZ R-45768-775; MCZ A-24288) from Karakelong Island collected by the first FAIRCHILD Tropical Botanic Garden Expedition led by the late David FAIRCHILD (1869-1954). This expedition made a short stop-over at the Talaud Islands from 12 to 13 June 1940. The collection merely contains nine specimens representing five lizard species (*Bronchocela cristatella*, *Emoia caeruleocauda*, *Hemidactylus frenatus*, *Lipinia noctua*, and *Eutropis m. multifasciata*) as well as one snake (*Candoia paulsoni tasmai*) and one hylid frog species (*Litoria infrafrenata*). To our knowledge, only McDOWELL (1979), BROWN (1991) and SMITH et al. (2001) referred, in part, to the FAIRCHILD collection. Therefore, these voucher specimens are included in our report.

This checklist of the Talaud Islands summarizes the present-day knowledge of the herpetofauna and discusses the biogeographic relations and implications of these data. It is the first updated account of the amphibians and reptiles of this remote oceanic archipelago since 80 years.

2. MATERIAL AND FIELD WORK

Field studies on the east coast of Salibabu Island (ca. 95 km²) were conducted by AK and EA from 13 to 21 July 2005. Collections and observations were made in the vicinity of Lirung, a settlement with a ferry landing stage. Field numbers are AK039 to AK075. The surroundings near the coastline are dominated by agricultural vegetation, especially coconut (*Cocos nucifera*) and nutmeg (*Myristica fragrans*) plantations (Fig. 3). The island's hilly interior was not intensively surveyed. In the low central hills, however, primary habitats or at least areas of minor disturbance still exist (Fig. 4). As recently recognized by RILEY (2002), and unlike the neighboring island Salibabu, large areas of Karakelong Island (ca. 970 km²) are still



Fig. 3. Coconut and nutmeg plantations dominate the cultivated coastal landscape of Salibabu Island. Red arrow indicates *Varanus* sp. basking on a palm trunk. Photo by André Koch.



Fig. 4. Undisturbed riverine habitat upcountry of Salibabu Island. Habitat of *Limnonectes* sp. and an unidentified snake species. Photo by André Koch.

forested. Surveys were done throughout all hours of day and early night. Specimens were mainly collected manually and with the assistance of a local villager. Voucher specimens were photographed prior to and after euthanization and preserved in 70 % ethanol. They are deposited in the Zoological Museum in Bogor (MZB). Tissue samples of monitor lizards were taken for molecular investigations and preserved in 95 % ethanol. Photographic vouchers are deposited in the private photo collections of AK and EA.

Species determination and distribution records follow BOETTGER (1895a, b; 1903), BOULENGER (1897), BARBOUR (1912), DE ROOIJ (1913; 1915; 1917), VAN KAMPEN (1923), DE JONG (1928), MERTENS (1929), PARKER (1934), TANNER (1950), BROWN & ALCALA (1970), BROWN & ALCALA (1980), BROWN (1991), MONK et al. (1997), HALLERMANN (2005), DE LANG & VOGEL (2005), and ZIEGLER et al. (2007). All species known from the Talaud Islands are listed in Table 1. Abbreviations used are: SVL – snout vent length; TL – tail length; TiL – tibia length. Measurements are given in mm. Museum acronyms are as follows: CAS – California Academy of Science, San Francisco, USA (CAS-SU denotes the Stanford University collection [SU], which is also housed in the CAS); MCZ – Museum of Comparative Zoology, Cambridge, USA; MTD – Museum of Zoology (Museum für Tierkunde), Dresden, Germany; MZB – Museum Zoologicum Bogoriense, Cibinong, Indonesia; RMNH – Nationaal Natuurhistorisch Museum Naturalis, Leiden, Netherlands; ZFMK – Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany; ZMA – Zoological Museum, University of Amsterdam, Netherlands.

Information about ZMA specimens was taken from the online database at <http://ip30.eti.uva.nl/zmawebsite/search-specimens.php>.

The website <http://collections.oeb.harvard.edu/Herp/Rept-Search.htm> provides information on Talaud specimens in the MCZ collections.

3. RESULTS

ANNOTATED CHECKLIST OF THE AMPHIBIANS AND REPTILES OF THE TALAUD ISLANDS

AMPHIBIA

Hylidae

Litoria infrafrenata (Günther, 1867) (Fig. 5)

Material examined: MZB Amph. 11480, 11490, 11492 (AK039-040, AK072)

Additional material: MCZ A-24288, Karakelong, coll. FAIRCHILD Garden Expedition 1940; ZMA 8570 (3 spec.), Lirung, Salibabu, coll. M. WEBER 1899; ZMA 8576 (1 spec.), Beo, Karakelong, coll. M. WEBER 1899.



Fig. 5. *Litoria infrafrenata* from Salibabu Island. Photo by André Koch.

Distribution: VAN KAMPEN (1907) was the first to record this species for the Talaud Islands (at that time as *Hyla dolichopsis* Cope, 1867, a junior synonym of *L. infrafrenata*). According to BARBOUR (1912) it "(...) is the most widespread *Hyla* of this whole region [i.e. the Indo-Australian Archipelago]". He listed four female specimens from Lirung and Beo, on Salibabu and Karakelong, respectively. Later however, VAN KAMPEN (1923) only states "Talaud Islands" without specifying the exact locality.

Morphology: VAN KAMPEN (1907) mentioned that disk size varies in this species. Thus, in specimens from Lirung for instance, the disks are smaller than the tympanum (in one specimen three vs. four mm). The same relation applies to our voucher specimens where the disks are also smaller than the eye diameter. SVL of largest specimen (MZB Amph. 11492) 115.5 mm; TiL: 62 mm. Males exhibit black rugosities on the inner side of the first finger. This is the case in our specimen MZB Amph. 11480.

Microhylidae

Callulops cf. dubius (Fig. 6)

Material examined: MZB Amph. 11443 (AK047), MZB Amph. 11469 (AK054), MZB Amph. 11470 (AK053), MZB Amph. 11496 (AK074), MZB Amph. 11500 (AK052).

Distribution: Our findings on Salibabu Island expand the known range of the genus by approximately two hundred kilometers to the north and represent a new family record for the Talaud Islands.

Ecology: Subadult and adult voucher specimens were either found in small holes near the base of trees (Fig. 6), or after rainfall near a small stream in the early evening hours (7.30–8.30 pm).

Morphology & Taxonomy: Characteristically short-snouted, small frogs with short limbs: SVL 23.0–39.6 mm, TiL 9.5–15.5 mm; dorsally uniform dark brown to gray-



Fig. 6. *Callulops cf. dubius* from Salibabu Island. Photo by André Koch.

ish black, ventral side either uniform light grey or dark grey with more or less light mottling, toes with weak light transverse bands.

The Talaud population may represent a member of the *Callulops (Phrynomantis) robustus* group (R. GÜNTHER, pers. comm.). The genus *Callulops* inhabits the Moluccas, New Guinea and surrounding island groups with 17 recognized species (FROST 2007), two of which (*C. boettgeri* and *C. dubius*) are found on Halmahera. According to MÉHELY (1901) and PARKER (1934) *C. boettgeri* is characterized by large triangular discs at fingers and toes, while those of the fingers are larger than those of the toes. Having the finger tips pointed and those of the toes slightly enlarged, fingers and toes without webbing, no maxillary teeth, a smooth skin above and beneath, the nostril much closer to the tip of the snout, tympanum feebly distinct and about half the diameter of the eye, presence of a supratympanic fold (but absent in MZB Amph. 11443 and 11500, possibly due to preservation), our voucher specimens resemble more the second *Callulops* species known from Halmahera, *C. dubius* (BOETTGER 1895b). However, in contrast to the latter species, the first finger is longer than the second in the Talaud specimens. It cannot be ruled out that the Talaud specimens represent two distinct species due to their differences in ventral color pattern and the presence or absence of a supratympanic fold.

Ranidae

Limnonectes cf. modestus (Boulenger, 1882)

Material examined: MZB Amph. 11478 (AK073), 11493 (AK068), 11494 (AK050), MZB Amph. 11497 (AK051).

Additional material: Probably ZMA 8870 (5 spec.), "Taloek, island North of Halmahera" (= Talaud?!), coll. M. WEBER 1900

Distribution: Based on material collected by the Siboga Expedition of Max WEBER (six specimens according to van Kampen [1907], but only five according to the ZMA online catalogue; see 'additional material'), VAN KAMPEN (1907) was the first to record *L. modestus* from the Talaud Islands without indicating the exact locality. This species is also known from North Sulawesi, the type locality, and some islands in the Moluccas. The Philippine populations have been removed from the synonymy of *L. modestus* (INGER 1954).

Ecology: While two adult voucher specimens were collected near a small stream in the vicinity of the village Lirung, the third (MZB Amph. 11493) was found as road kill next to a coconut plantation.

Morphology & Taxonomy: All three adult specimens closely resemble in morphology and coloration. SVL 58.6–63.6 mm, TiL 32.7–33 mm, head as broad as long or broader than long; vomerine and maxillary teeth present; nostril nearer to tip of snout than to eye; tympanum distinct, 3/4 the diameter of the eye; strong supratympanic fold; finger tips pointed, those of the toes with very small discs; first finger slightly longer than second; fingers without webbing, toes nearly fully webbed; dermal fringe along the outer side of fifth toe present; inner palmar tubercle swollen, outer missing; inner metatarsal tubercle present, outer missing; skin smooth without ridges or tubercles. Coloration dorsally olive-green to brownish with little dark spots; tympanum partly blackish; supratympanic fold above tympanum black; upper lips with dark vertical bars; limbs without dark cross bars; posterior part of thighs blackish with orange marbling; ventral side either unicolored whitish cream under head and chest, limbs and posterior half of venter orange, particularly towards vent (MZB Amph. 11494), or underside whitish with grey mottling under head and many grey spots and blotches on chest and venter. Probably three females were collected without vocal sacs. Accordingly, the specimens lack bony processes in the lower jaw as typical for males of *L. modestus*. A fourth subadult specimen of *Limnonectes* was collected in a narrow gorge with a small riverine (Fig. 4). SVL 27.3 mm, TiL 13.8 mm, head slightly longer than broad. Morphologically, this specimen resembles the three adult specimens, except for the indistinct supratympanic fold. However, it shows differences in color pattern. Thus, the dorsal side is brown with distinct darker cross bars and blotches on the limbs; a dark cross bar between the eyes is present, too; the distinct marbling on the posterior part of the femurs is missing.

MENZIES (1987) suggested that populations of Sulawesi and Ceram might represent different taxa. Further investigations, morphologically and genetically, are needed to clarify the taxonomic identity of the Talaud populations.

SAURIA

Agamidae

Bronhocela cristatella (Kuhl, 1820) (Fig. 7)

Material examined: MZB Lac. 5080 (AK057).

Additional material: ZMA 18832 (4 spec.). Gunung Doeata (= Mt. Duata), Karakelong, coll. H. J. LAM, 1926; ZMA 18833, Lirung, Salibabu, coll. H. J. LAM, 1926; MCZ R-45770, -771, Karakelong, coll. FAIRCHILD Garden Expedition, 1940



Fig. 7. *Bronchocela cristatella* from Salibabu Island. Photo by André Koch.

Distribution: DE JONG (1928) reported that H. J. LAM collected several specimens of *B. cristatella* on Karakelong and Salibabu Island. Two further specimens were collected by the FAIRCHILD Expedition in 1940. As neither of these old voucher specimens has been included in a recent review of the genus *Bronchocela* (HALLERMANN 2005), their taxonomic identification requires verification. Nevertheless, our investigations confirm that *B. cristatella* also inhabits the Talaud Archipelago next to Sulawesi, the Philippines and the Moluccas.

Ecology: The voucher specimen (MZB Lac. 5080) was found on a tree trunk near three small fish ponds where *Hydrosaurus* also occurred. Another subadult specimen of *Bronchocela* was discovered sitting on a thin branch above a small stream near Lirung village.

Morphology: SVL 89 mm, TL 298 mm (TL/SVL: 3.34); eight supralabials; nine infralabials; 55 scales around mid-body, the first five to six upper scale rows of the lateral side keeled and pointing upwards; ventral scales larger than dorso-laterals; 35 strongly keeled scales under fourth toe; six to seven scales along canthus rostralis between nostril and anterior border of orbit; diameter of tympanum more than half diameter of orbit (0.83).

Bronchocela jubata Duméril & Bibron, 1837

Material examined: none

Additional material: ZMA 18866, Lirung, Salibabu, coll. M. WEBER 1899; ZMA 18869, Beo, Karakelang (= Karakelong), coll. M. WEBER 1899.

Distribution & Taxonomy: Because HALLERMANN (2005) did not examine the ZMA specimens collected by WEBER, he stated that older records of *B. jubata* from the Talaud Islands by DE ROOIJ (1915) may be correct. However, 14 specimens from Sulawesi formerly deposited in the Leiden collection (RMNH 3021a-e, 3023a-d, and 7419a-e) as *B. jubata*, were redetermined by HALLERMANN (2005) as *B. celebensis*, which is endemic to Sulawesi. In turn, three older records of *B. jubata* from Sulawesi in the Berlin collection (ZMB) are correct according to this author. From the entire Philippine Archipelago only one voucher specimen from Mindanao (ZMB 16305) was included in the review by HALLERMANN (2005). Four further specimens (ZMB 34117) allegedly from the Philippines lack specific locality data. Thus, it remains uncertain if two different species of *Bronchocela* live in sympatry on the Talaud Islands. Pending molecular genetic studies and further field work will hopefully reveal the systematics and the exact distributions of these morphologically diverse agamids.

Hydrosaurus sp. (Fig. 8)

Material examined: MZB Lac. 5081 (AK049).

Distribution: DE JONG (1928) reported *Hydrosaurus amboinensis* for Karakelong Island. This is the first record of this large agamid for Salibabu Island.

Ecology: During recent field surveys on Salibabu Island three adult specimens were flushed out. One female specimen was observed sitting on a tree with remarkable thin branches. One juvenile voucher specimen was encountered near a small fish pond. On Talaud, *Hydrosaurus* displays a cryptic life style and seems to avoid the coast line. This agamid species prefers less anthropogenically influenced inland habitats with freshwater environment.

Morphology: SVL 116.5 mm, TL 243 mm; tympanum diameter 3.1 mm; dorsal crest missing, nuchal crest indicated by a row of 16 prominent scales; six to seven interocularia; 11 supralabials, sixth to eleventh under eye; 11 infralabials; mental large; one row of six and seven enlarged submaxillaries, respectively, separated from infralabials by one (first IL) or several small scales; lateral scales heterogeneous, mainly small and strongly carinate, interspersed



Fig. 8. *Hydrosaurus* sp. from Salibabu Island. Photo by André Koch.

with six groups of two to six tubercular, carinate scales; three further such enlarged scales along the side of the neck; towards the ventral side numerous enlarged, smooth scales arranged in more or less distinct transverse rows; ventral scales homogenous, smooth; subdigitals under fourth toe small at basis, followed by 35 relatively enlarged subdigitals after first phalanx; toes laterally with a row of extremely wide (up to 1.9 mm) scales, 36 at fourth toe forming a serrated edge. Ten and eleven femoral pores, respectively. Ground color green to brownish with enlarged scales of the dorsal and lateral side being lighter; ventral side whitish, throat darker.

Taxonomy: Phenetically, the Talaud specimen resembles a juvenile *H. pustulatus* from Panay Island, central Philippines, in color pattern and scalation (photo courtesy of M. Gaulke). However, a systematic assignment of the Talaud population either to *H. amboinensis* from Sulawesi, *H. pustulatus* from the Philippines, *H. weberi* from Halmahera or to another hitherto unrecognized taxon seems premature at this time, due to the lack of diagnostic characters (dorsal and nuchal crests, adult color pattern) in the juvenile voucher specimen and insufficient material for comparison of the three *Hydrosaurus* taxa currently recognized.

Gekkonidae

Cyrtodactylus cf. *jellesmae* (Boulenger, 1897)

Material examined: MZB Lac. 5126 (AK056), MZB Lac. 5128 (AK055).

Additional material: ZMA 15942 (1 spec.), Gunung Doeata (= Mt. Doata), Karakelong, coll. H. J. LAM 1926; ZMA 17884 (1 spec.), same data as previous specimen.

Distribution: DE JONG (1928) reported one specimen (but see 'additional material') of *C. marmoratus* from Karakelong Island. However, BRONGERSMA (1934) showed that Sulawesi specimens of *C. marmoratus* were referable to *C. fumosus*. Accordingly, ISKANDAR & NIO (1996) doubted the occurrence of *C. marmoratus* on Sulawesi as previously mentioned (e.g., DE ROOIJ 1915). This is the first record of *C. cf. jellesmae* for Salibabu Island and the northernmost occurrence of the entire range of this species.

Ecology: Both voucher specimens, apparently a female and a male (the female carrying two well-developed eggs which are visible through the thin skin), were found at 20.30 p.m. at low elevations on the trunks of a tree and a coconut palm, respectively.

Morphology: Both sexes lack preanal and femoral pores and the ear openings are oval as characteristic for *C. jellesmae* (BOULENGER 1897; DE ROOIJ 1915). Lateral fold present between axilla and groin. However, in coloration and scalation the Salibabu population differs from those of Sangihe Island and north Sulawesi. The characteristic dark, V- and M-shaped dorsal markings are less distinct and the tubercles have light tips only laterally. In addition, the Talaud population shows less pronounced tubercles on dorsum, legs and tail. From the new described species, *C. wallacei*, the Talaud geckos are distinguished by the absence of enlarged subcaudal scales (HAYDEN et al. 2008).

Taxonomy: Probably DE JONG's (1928) specimen from the Talaud Islands will prove to belong to *C. cf. jellesmae* which was frequently found on Sulawesi and adjacent islands compared to *C. fumosus* and *C. wallacei* (unpubl. data). Future molecular studies are required to enlighten the systematics and taxonomy of this morphologically cryptic complex of gecko species in the Sulawesi region.

Gehyra mutilata (Wiegmann, 1834)

Material examined: MZB Lac. 5124 (AK046).

Distribution: *Gehyra mutilata* is herein reported for the first time for the Talaud Islands. This invasive gecko species inhabits Southeast Asia, Oceania, Madagascar, Mexico, California, Hawaii, and New Zealand. It was probably accidentally introduced from the Philippines or North Sulawesi by human transportation.

Ecology & Morphology: The voucher specimen, a female containing two eggs, was collected on the wall of a house in Lirung village where several specimens were observed. SVL 50 mm, TL 53 mm.

Gekko vittatus Hottuyn, 1782

Material examined: none

Distribution: In the distribution table of “East Indian” herptiles, BARBOUR (1912: 179) listed the Talaud Islands within the range of *Gekko vittatus*. This gecko species is known from the Moluccas, New Guinea and surrounding archipelagos. Thomas BARBOUR himself did not visit the Talaud Islands but he was aware of VAN KAMPEN’s (1907) account about amphibians based on Max WEBER’s collections from that island group. The correctness of BARBOUR’s (1912) data cannot be proven as no information on voucher specimens was provided. Theoretically, however, the occurrence of this gecko species on the Talaud Archipelago seems possible as other Australopapuan species also inhabit this island group. Future investigations in the herpetofauna of the Talaud Islands may answer this question.

Hemidactylus frenatus Duméril & Bibron, 1836

Material examined: none

Additional material: MCZ R-45768, and R-45769, Karakelong, coll. FAIRCHILD Expedition 1940.

Distribution & Ecology: This circum-tropically distributed gecko species was frequently seen on walls of houses. Our observations suggest that *H. frenatus* and *G. mutilata* are more common on Talaud than on neighboring Sangihe Island. Two voucher specimens (see ‘additional material’) of the FAIRCHILD Expedition are deposited in the MCZ collection.

Nactus pelagicus complex (Fig. 9)

Material examined: MZB Lac. 5086 (AK075).

Ecology: During daytime one specimen was found under a rotten tree trunk in a hilly area near Lirung on Salibabu Island.

Morphology: SVL 54 mm; tail regenerated, 55 mm long, fifth toe of left hind limb missing; probably a female, pre-anal pores missing; dorsum, limbs and tail (except for regenerated part) covered with granules and conical tuber-



Fig. 9. *Nactus* cf. *pelagicus* from Salibabu Island. Photo by André Koch.

cles forming six regular longitudinal rows on the back, irregularly arranged along the lateral sides; rostral large; only 5 supralabials (as compared to other populations); 7 infralabials; mental large, a pair of small chin-shields posterior to the mental; ventral side covered with small granulous scales; 19 subdigits under fourth toe. Coloration of dorsal side dark brown with blackish blotches on the back, increasing in number towards the snout, labial sutures whitish; ventrally dark grayish-brown, regenerated tail with irregular light markings.

Distribution & Taxonomy: This is the first record of the genus *Nactus* for the Talaud Islands representing the northern most population of this widespread Pacific species group which is known to consist of bisexual and parthenogenetic species (MORITZ 1987; DONNELLAN & MORITZ 1995; ZUG 1998). The taxonomic status of most New Guinean population is still uncertain (KRAUS 2005; JACKMAN et al. 2008). Traditionally, they have been assigned to *N. pelagicus* and *N. vankampeni*, but unisexual *N. pelagicus* have been shown to be restricted to southern Vanuatu, New Caledonia, and Oceania (ZUG & MOON 1995). TANNER (1950) reported a specimen from Morotai close to Halmahera which was obviously a male because it “(...) has an angular series of 7 preanal pores”.

Scincidae

Emoia a. atrocostata (Lesson, 1826) (Fig. 10)

Material examined: MZB Lac. 5130 (AK071).

Additional material: RMNH 18659, Karakelong, coll. Snellius Expedition (Dr. H. BOSCHMA), 14–21 June 1930.



Fig. 10. *Emoia a. atrocostata* from Salibabu Island. Photo by André Koch.

Distribution: According to BROWN (1991) the Talaud population of *E. atrocostata* belongs to the nominotypic subspecies. He examined one specimen from Karakelong (RMNH 18659). This coastal skink species is widespread ranging from the Philippines through the Indo-Australian Archipelago and many Pacific island groups such as the Carolines and Palau reaching North Australia. This is the first record of *E. a. atrocostata* for Salibabu Island.

Ecology: The voucher (MZB Lac. 5130), a weak adult specimen infested with several red mites (Acari), was resting on coral limestone with temporary ponds at the shoreline where this species was frequently found on Salibabu Island (Fig. 2). Early activity was observed at 7 a. m. although the sky was cloudy and temperatures were relatively low.

Morphology: SVL 85.4 mm, tail short, laterally compressed, 73.6 mm long; TL/SVL 0.86; seven supralabials, fifth enlarged and below eye; tympanum small; lower eyelid with a transparent disk; one pair of nuchals; 38 mid-body scale rows; 33 rounded lamellae under fourth toe.

Emoia caeruleocauda (de Vis, 1892)

Material examined: MZB Lac. 5114 (AK043), MZB Lac. 5115 (AK041), MZB Lac. 5118 (AK042), MZB Lac. 5127 (AK069).

Additional material: MCZ 45774, coll. FAIRCHILD Expedition, 1940; ZMA 18384 (1 spec.), Liroeng (= Lirung), Salibabu, coll. M. WEBER 1899; ZMA 18391 (as *Lygosoma triviale*; 2 spec.), Beo, Karakelong, coll. H. J. LAM 1926; ZMA 18392 (as *Lygosoma triviale*; 5 spec.), Gunung Doeata (= Mt. Doata), Karakelong, coll. H. J. LAM 1926; ZMA 18395 (as *Lygosoma triviale*), Liroeng (=

Lirung), Salibabu, coll. H. J. LAM 1926; ZMA 18409 (as *Lygosoma triviale*; 1 spec.), Beo, Karakelong, coll. M. WEBER 1899.

Distribution & Taxonomy: The Talaud population was formerly recognized as *E. cyanura* (DE ROOIJ 1915; DE JONG 1928), which in contrast to *E. caeruleocauda* is widely distributed in Pacific islands from the Bismarck Archipelago eastwards (BROWN 1991). BROWN (1991) revised the genus and identified one specimen (MCZ 45774) from Karakelong as *E. caeruleocauda*.

Morphology: According to Brown (1991), these phenetically similar species (*E. cyanura* and *E. caeruleocauda*) can be distinguished by the shape and number of lamellae under the fourth toe. Two specimens from Salibabu (MZB Lac. 5115, 5127) each had 44 lamellae under the fourth toe, thus confirming the occurrence of *E. caeruleocauda* on the Talaud Archipelago. Lower eyelid with a transparent disk; hind limb reaches the axilla.

Ecology: On Salibabu Island *E. caeruleocauda* was frequently found on the ground and low vegetation. It is the most common lizard of the Talaud Archipelago. These conspicuous lizards use their metallic-blue tail fluttering from side to side to distract potential predators, mark male territories and attract potential mates.

Eugongylus rufescens (Shaw, 1802)

Material examined: none

Additional material: ZMA 12491 (4 spec.), Gunung Doeata (= Mt. Duata), Karakelong, coll. H. J. LAM 1926; ZMA 12492 (1 spec.), Lirung, Salibabu, coll. M. WEBER 1899

Distribution: DE ROOIJ (1915) listed *Eugongylus rufescens* for Salibabu Island and DE JONG (1928) reported another specimen of this skink from Karakelong (according to the online ZMA database 4 specimens are summarized under collection number ZMA 12491). We could not find this species during our field work. The Talaud populations represent the most north-western distribution of this short-legged skink which inhabits New Guinea, the Solomon and Admiralty Islands finally reaching northern Australia.

Eutropis m. multicarinata (Gray, 1845) (Fig. 11)

Material examined: MZB Lac. 5084 (AK063), MZB Lac. 5085 (AK062), MZB Lac. 5087 (AK061), MZB Lac. 5116 (AK060), MZB Lac. 5117 (AK058).



Fig. 11. *Eutropis m. multicarinata* from Salibabu Island. Photo by André Koch.

Additional material: ZMA 18454 (1 spec.), Beo, Karakelong, coll. M. WEBER 1899.

Distribution: DE ROOIJ (1915) recorded *Eutropis multicarinata* (at that time still in the genus *Mabuia*, but taxonomically partitioned by MAUSFELD et al. [2002]) from Karakelong Island. Our findings represent the first record of this species for Salibabu Island. Thus, on the Talaud Islands *E. multicarinata* has its most south-eastern distribution.

Ecology: Five specimens were collected in the vicinity of Lirung (partly at night, 8.30 p.m.) while resting at the base of a tree. During daytime, brown skinks, though undetermined, climbed up tree trunks when chased. These observations suggest that *E. multicarinata* is adapted to a semi-arboreal life style.

Morphology: According to DE ROOIJ (1915), *E. multicarinata* can be distinguished from the phenetically similar species *E. rudis* and *E. multifasciata* by the absence of postnasal scales and five or seven strong keels on nuchals, dorsals and laterals. According to BROWN & ALCALA (1980) *E. multicarinata* has 22 to 29 lamellae (usually 24–28) beneath the fourth toe, while *E. multifasciata* has only 16 to 21, and *E. rudis* 18 to 22. Furthermore, these authors provide the following scalation data. *E. multicarinata* has 28 to 32 scales around midbody, while *E. multifasciata* has 30 to 34, and *E. rudis* 28 to 32. All specimens match the definitions by DE ROOIJ (1915) and BROWN & ALCALA (1980) in having six or seven keels on dorsals (fused nuchals with up to 11 keels!), 22 to 25 lamellae beneath fourth toe, and 32 to 33 scales around midbody. At least in one specimen (MZB Lac. 5087) the postnasal is absent. However, in MZB Lac. 5084 and MZB Lac. 5085 a postnasal is present. The prefrontals are separated by the frontal. The dorsal side is brown, sometimes interspersed

with few darker spots, laterally with a dark brown streak from behind the eyes along the body, sometimes bordered above by a light brown streak; ventral side light yellowish to grey, throat in three specimens bluish-grey; supralabials also grayish. The Talaud population of *E. multicarinata* can be assigned to the nominal subspecies because the parietals are separated by the interparietal. All voucher specimens, however, lack blackish spots or blotches below the head and throat as characteristic for *E. m. borealis* (BROWN & ALCALA 1980).

Eutropis multifasciata (Gray, 1845)

Material examined: none

Additional material: MCZ R-45772 and MCZ R-45773, Karakelong, coll. FAIRCHILD Garden Expedition 1940.

Distribution: *Eutropis multifasciata*, a widespread species known also from Sulawesi, the Philippines and Halmahera in the Moluccas, was not found during this biodiversity survey. However, more than 60 years ago, the FAIRCHILD Garden Expedition collected two specimens (see 'additional material') of this skink on Karakelong which have not yet been reported. We provide here the first record of this skink from the Talaud Island. In addition, H. J. LAM collected this species on Miangas north of the Talaud Islands (DE JONG 1928).

Taxonomy: Although *E. multifasciata* is known to occur sympatrically with its congeners *E. multicarinata* and *E. rudis* on Mindanao in the Philippines (BROWN & ALCALA 1980), the identification of the FAIRCHILD voucher specimens should be re-confirmed due to the observed differences in scalation characters in *E. multicarinata* and *E. cf. rudis* (see below).

Eutropis cf. rudis (Boulenger, 1887) (Fig. 12)

Material examined: MZB Lac. 5142 (AK044), MZB Lac. 5113 (AK070).

Ecology: Two subadults (MZB Lac. 5142: SVL 36.8 mm, TL 50.0 mm; see Fig. 12) were collected near Lirung on Salibabu Island in a coconut and nutmeg plantation and on the beach, respectively.

Morphology & Taxonomy: To distinguish *E. rudis* from *E. multifasciata*, BROWN & ALCALA (1980) mention that the prefrontals are in broad contact in the latter species while they are usually narrowly separated (or rarely in contact) in *E. rudis*. Aside this scalation character, both voucher specimens largely agree with the definition by BROWN



Fig. 12. *Eutropis* cf. *rudis* from Salibabu Island. Photo by André Koch.

& ALCALA (1980) in having 20 and 22 keeled lamellae under fourth toe, 32 and 30 midbody scale rows (usually 28–30, rarely 31 or 32; 28–31 in *E. rudis* from Sulawesi according to HOWARD et al. [2007]), respectively. A postnasal is present. The hind limbs of MZB Lac. 5142 reach the axilla as postulated by DE ROOIJ (1915), while MZB Lac. 5113 exhibits tricarinate dorsals as typical for *E. rudis*. The second specimen's dorsal scales have up to five keels (very rarely in *E. rudis* according to BROWN & ALCALA [1980]), of which the three medians are strongly pronounced and flanked by two feeble outer keels. The Talaud specimens share this character with the newly described *E. grandis* from Sulawesi (HOWARD et al. 2007), from which, however, they are clearly distinguishable by higher midbody scale counts (30–32 vs. 25–27 in *E. grandis*). In contrast to BROWN & ALCALA (1980) and HOWARD et al. (2007) both vouchers have 40 paravertebral rows (vs. 34–38 in Philippine *E. rudis* and 34–35 in Sulawesian *E. rudis*, respectively) between parietals and base of tail. The dorsal side is brown, laterally with a dark brown streak starting behind the nostrils, bordered above by a light brown streak; ventral side light grey, supralabials also grayish. In specimen MZB Lac. 5113 the ventral side is light gray only on the first half of the body; the rest including hind limbs and tail is brownish.

Because both voucher specimens are not fully grown, the identification as either *E. rudis* or *E. multifasciata* is not unequivocal. Deviations in vertebral scale counts from those provided by BROWN & ALCALA (1980) may be explained by geographic variation. Therefore, we here preliminarily allocate them to *E. cf. rudis*. Further investigations will reveal if *E. rudis* really inhabits the Talaud Islands.

Lamprolepis smaragdina ssp. (Lesson, 1830) (Fig. 13)

Material examined: none

Additional material: ZMA 11304 (1 spec.), Karakelang (= Karakelong), coll. H. J. LAM 1926; ZMA 18231 (1 spec.), Liroeng (= Lirung), Salibabu, coll. H. J. LAM 1926.



Fig. 13. *Lamprolepis smaragdina* ssp. from Salibabu Island. Photo by André Koch.

Distribution & Taxonomy: DE JONG (1928) reported two specimens of *L. smaragdina* from the Talaud Islands. MERTENS (1929), who examined DE JONG's voucher specimens mentioned that despite their minor geographic distance to the Philippines the Talaud specimens (and even those of the Miangas further north to Mindanao) resemble *L. smaragdina viridipuncta* inhabiting the Pacific archipelagos of Palau, the Carolines, and eastward to the Marshall Islands. Nevertheless, he allocated the Talaud population to the Philippine subspecies *L. s. philippinica*. MERTENS (1929) remarked that one specimen from Lirung, Salibabu, was the largest of more than 100 voucher specimens he examined from all over the species' range; its SVL measured 114 mm, and the black markings typical of Philippine populations were largely reduced. This pattern of *L. s. viridipuncta* was also found in the only specimen from Mindanao available to MERTENS (1929). He finally designated the Talaud and Miangas populations as a hybrid form of the Philippine and Pacific taxa.

Morphology: Observations and photographs of a few adult specimens active on trees and coconut palms near the coast of Lirung match MERTENS' (1929) description of the Salibabu specimen. The uniformly green coloration without any markings is different from populations of *L. smaragdina* on both neighboring islands of Sangihe and north Sulawesi. No specimens of the *viridipuncta* subspecies were examined.

Lipinia noctua (Lesson, 1826)

Material examined: none

Additional material: ZMA 18348, Gunung Doala (= Mt. Doala), Karakelong, coll. H. J. LAM 1926; MCZ R-45775, Karakelong, coll. FAIRCHILD Garden Expedition 1940

Distribution: The record for Talaud by DE JONG (1928) was not mentioned by ZWEIFEL (1979) who examined the variation in the moth skink, *Lipinia noctua*. A second specimen (MCZ R-45775) was collected by the FAIRCHILD Expedition. The Talaud population represents the most north-westerly distribution for this cosmopolitan Pacific species. During our survey we could neither record this species, nor could we examine DE JONG's voucher specimen.

Varanidae

Varanus sp. (aff. *indicus* Daudin, 1802) (Figs 3, 14)

Material examined: MZB Lac. 5176 (AK067), MZB Lac. 5177 (AK064), MZB Lac. 5178 (AK059), MZB Lac. 5179 (AK066), MZB Lac. 5180 (AK065); MZB Lac. 581 (954),



Fig. 14. *Varanus* sp. from Salibabu Island. Photo by André Koch.

Karakelong Island, coll. H. J. LAM 1926; MZB Lac. 4195, Beo, Karakelong Island, coll. J. RILEY of WCS (World Conservation Society) 9 June 1999; ZMA 15411b, Lirung, Salibabu, coll. M. WEBER and Siboga Expedition 25-27 July 1899; ZFMK 87587 (formerly ZMA 15411a), same data as previous specimen.

Distribution: The Talaud population represents the most north-westerly distribution of a member of the *Varanus indicus* species group (ZIEGLER et al. 2007). Interestingly, AUFFENBERG (1980: 109) listed two specimens of *V. salvator* from Liroeng (= Lirung) on Salibaboe (= Salibabu) Island in the collection of the Museum Zoologicum Bogoriense (MZB Lac. 947 and 954, respectively). These vouchers, however, could not be located in the MZB collection. According to the MZB herpetology catalogue, the collection numbers to which AUFFENBERG (1980) referred belong to a specimen of *V. cf. nebulosus* and *V. indicus*, respectively (I. SIDIK pers. comm.). The latter was collected by H. J. LAM on Salibabu Island in 1926. Accordingly, we could not confirm a potential co-existence of Pacific monitor lizards with the water monitor, *V. salvator*, on Salibabu Island. Although local people reliably stated that there are two giant reptile species found on the island, the description of the second species fits exactly with the large sailfin lizard, *Hydrosaurus*.

Ecology: On Salibabu Island monitor lizards are frequently found in disturbed and cultivated areas like coconut plantations near the coast line. Thus, a preference for salt-water influenced habitats as reported for *V. indicus* on New Guinea (PHILIPP 1999) could also be confirmed for the Talaud monitor lizards. Five mature specimens were found during day time on palm or tree trunks while basking or mating (Fig. 3). Only once, a juvenile specimen was flushed out near a tunnel but escaped in the dense vegetation. These observations suggest an ecological separa-



Fig. 15. Defecated prey remains from specimen MZB Lac. 5178 of *Varanus* sp. representing a large orthopteran (*Sexava* sp., Tettigoniidae) and fragments of a crab.

tion of different age groups in the Talaud monitor lizards. While juvenile specimens seem to hide in thicket on the ground, adults obviously prefer a semi-arboreal life. The avoidance behaviour of juveniles seems reasonable because cannibalism is common in many monitor lizard species.

Although monitor lizards are regularly hunted for food supply by local people, no direct threat of the Salibabu population could be recorded. Natural predators are scarce as no large carnivorous mammals are known from these islands (RILEY 2002). However, crocodiles (*Crocodylus* sp.) and the reticulated python (*Python reticulatus*) should be considered natural predators.

Diet: After being caught specimen MZB Lac. 5178 defecated the undigested remains of a small crab and a large green orthopteran (*Sexava* sp., Tettigoniidae) (Fig. 15). Furthermore, the stomach of ZFMK 87587 contained a well-preserved specimen of a large spider ("*Olios*" *coccineiventris* group, Deleninae) and a fragmented crab. These findings are in congruence with our observations of an arboreal-aquatic life habit in the Talaud monitor lizards.

Parasites: Some specimens exhibited several ticks (probably *Amblyomma* sp.) on the ventral side mostly near the umbilical region and at the base of the tail.

Reproduction: Mating behaviour was observed near the coast only two meters alongside a dirt road at 10.30 a. m., 19 July 2005. Two monitor lizards (MZB Lac. 5177 and MZB Lac. 5180) in mating position were discovered at a palm trunk about six meters above ground. When a local collector climbed up the coconut palm, the pair uncoupled and both specimens tried to hide in the crown. One of the specimens even jumped down the palm to escape. This behaviour was observed twice while chasing monitor lizards on Salibabu Island.

In addition, two voucher specimens (ZFMK 87587 and MZB Lac. 5177) contained two and three eggs, respectively, suggesting that the reproductive period of Talaud monitor lizards occurs throughout May, June and July at least. The two small eggs are ca. 8 x 17 mm in size, while the three well-developed eggs measure 29 x 63 mm, 28 x 63 mm, and 27 x 61 mm, respectively.

Taxonomy: DE ROOIJ (1915), DE JONG (1928) and BRANDENBURG (1983) referred the Talaud population to the Pacific monitor lizard, *V. indicus*. However, due to particular characteristics in color pattern and pholidosis together with molecular genetic evidence (ZIEGLER et al. 2007), the Talaud monitor lizards represent a new member of the *V. indicus* species group (KOCH et al. subm.).

SERPENTES

Typhlopidae

Typhlops sp.

Material examined: MZB Serp. 3227 (AK045).

Distribution: First record of a blind snake species for the Talaud Islands.

Ecology: Two specimens were found under a coconut shell in a plantation near the coast of which one specimen was preserved.

Morphology & Taxonomy: ToL 130 mm; body width 2.2 mm; 255 ventrals, 13 or 14 subcaudals. The voucher specimen resembles the drawing of the holotype of *T. hedraeus* (CAS-SU 12346) depicted by IN DEN BOSCH & INEICH (1994) in having the eye restricted to the ocular scale not reaching the suture to the preocular; a subocular, in contrast to *T. ater* from Sulawesi, the Moluccas and New Guinea, is absent. However, the voucher differs from *T. hedraeus* in having two instead of one preocular and the latter is not smaller than the ocular. The upper jaw is not visible laterally. *T. hedraeus* is found on several Philippine Islands including Mindanao, Luzon and Negros, the type locality. Due to differences in morphology, the Talaud population may represent a distinct species.

Boidae

***Candoia paulsoni tasmai* Smith & Tepedelen in Smith et al. 2001 (Fig. 16)**

Material examined: MZB Serp. 2949, Niampak, Karakelong Island, 21 March 1999; MZB Serp. 2950, Essang, Karakelong Island, coll. WCS 5 April 1999.

Additional material: MCZ 45767 (paratype), Karakelong, coll. FAIRCHILD Garden Expedition 1940; ZMA 16937, Gunung Doeata (= Mt. Duata), Karakelong, coll. H. J. LAM 1926; ZMA 16943 (4 spec.), Liroeng (= Lirung), Salibabu, coll. M. WEBER 1899

Distribution: Beside Talaud, *C. paulsoni tasmai* inhabits Halmahera and surrounding islands as well as the tip of North Sulawesi (SMITH et al. 2001; DE LANG & VOGEL 2005). Consequently, the Talaud Islands are the most north-western population of this subspecies which is separated by about 800 km from the remaining subspecies of *C. paulsoni* on New Guinea and the Solomon Islands (SMITH et al. 2001). In contrast, *C. carinata* is found on Sangihe Island enclosed between *C. paulsoni* on the Talaud Islands in the north and the northern peninsula of Sulawesi in the south. However, historical records of *Candoia* from the "Minahassa" peninsula, North Sulawesi, by MEYER (1887) and independently by BOETTGER (1898) as adopted by BOULENGER (1897), DE ROOIJ (1917), STERNFELD (1920), McDOWELL (1979), IN DEN BOSCH (1985), ISKANDAR & NIO (1996), SMITH et al. (2001), and DE LANG & VOGEL (2005) may be incorrect as was repeatedly assumed for some others of MEYER's vertebrate collections (see HICKSON [1889: 158] and STRESEMANN [1939: 305] for birds and FEILER [1990] for mammals, respectively). Confusion of locality data may have easily occurred since MEYER did not exclusively undertake his collection on the Minahassa peninsula of Sulawesi, but also purchased many voucher specimens from Charles W. CURSHAM, a trader in Manado, who in turn sent out native hunters (MEYER & WIGLESWORTH 1898). Intense fieldwork in North Sulawesi in recent years has revealed no voucher specimens confirming the historical records (J. MCGUIRE pers. comm., KOCH & ARIDA unpubl. data). It is, therefore, reasonable to suggest that the "Minahassa" specimen (not present in the MTD collection and most probably lost dur-



Fig. 16. *Candoia paulsoni tasmai* (MZB Serp. 2950) from Karakelong Island. Photo by André Koch.

ing World War II, U. FRITZ & E. LEHR pers. comm.) actually originated from Talaud or Halmahera with its satellite islands, the actual range of *C. paulsoni tasmai*. The same may apply to BOETTGER's (1898; 1903) specimen (collected by W. KÜKENTHAL, presumably in the Senckenberg Museum collection, Frankfurt), which also lacks exact locality data.

Morphology: Although we did not find this snake species during our survey, two specimens (see 'additional material') collected on Karakelong Island by a team of WCS lead by Jon RILEY, were examined in the MZB collection. These specimens (SVL 524/650 mm, TL 78/80 mm; TL/SVL+TL: 0.13/0.11) fit the definition by SMITH & TEPEDELEN in SMITH et al. (2001) in having 30/31–37/38–26/26 scales around the body (anterior–midbody–posterior), 179/183 ventrals, 36/36 subcaudals, only one enlarged supraocular reaching the orbit, 11/11 circumorbitals, 10/10 supralabials (6–7/5–7 contacting orbit), 10/13 infralabials, dorsals keeled except for the second to fifth lateral rows; a distinctive white postanal spot is missing. The color pattern of the specimens varies. Specimen MZB Serp. 2949 shows a reddish-brown background color with darker blotches indicating a faded zigzag band dorsally, the head becoming dark brown towards the tip; ventral side beige with brown mottling or blotches. In contrast, specimen MZB Serp. 2950 (Fig. 16), like the Talaud specimen examined by SMITH et al. (2001), has a relatively light beige background color with a distinctive dark red-brown zigzag band dorsally and indistinctive brown blotches laterally; markings of the tail are dark brown. The ventral side shows nearly the same coloration as the dorsal with darker mottling and blotches.

Taxonomy: Earlier authors (e.g., DE ROOIJ 1917, DE JONG 1928, DE HAAS 1950, MCDOWELL 1979) referred specimens from the Talaud Islands to *Candoia carinata* (formerly known as *Enygrus carinatus*), which was later split into three different species, i.e., *Candoia carinata*, *C. superciliosa*, and *C. paulsoni* with several subspecies (SMITH et al. 2001). Based on only one voucher specimen (MCZ 45767 from Karakelong), these authors allocated the Talaud population of bevelnosed boas to a new subspecies, *C. paulsoni tasmai*.

Pythonidae

Python reticulatus (Schneider, 1801)

Material examined: none

Distribution: This widespread snake species inhabits continental South and Southeast Asia, the Philippines and Indonesia, east to the Moluccas and the Tanimbar Islands.

The reticulated python was reported from Bitunuris on Salibabu Island (DE LANG & VOGEL 2005).

Ecology: From Salibabu Island it was reported that a python approximately 5 m long had killed a child (KOPSTEIN 1927, 1930). DE LANG & VOGEL (2005) recounted several cases of persons devoured by pythons. They extrapolated that every year at least one human is eaten in Sulawesi by a reticulated python.

Taxonomy: As was shown by AULIYA et al. (2002), even small island populations like those from Tanahjampea and Selayar, located between the south-western peninsula of Sulawesi and Flores in the Lesser Sunda Islands, show subspecific differentiations. The Sangihe Island population also represents a distinct lineage (AULIYA et al. 2002). Therefore, the systematic status of the Talaud population compared to those of the Philippines, Sulawesi and the Moluccas is unclear and deserves taxonomic revision.

Colubridae

Remarks: One medium-sized brown snake disappeared under stones when encountered in a narrow gorge with a small stream (Fig. 4). Another small brown snake was encountered near the root of a tree, indicating that, apart from the following species, further unknown snakes inhabit the Talaud Islands.

Boiga irregularis (Bechstein, 1802)

Material examined: MZB Serp. 3238 (AK048).

Distribution & Ecology: The brown tree snake *Boiga irregularis* is a widespread species known from most islands east of Sulawesi, and reaching Australia. In some Pacific islands where *B. irregularis* was accidentally introduced, it has been responsible for a dramatic decline in the native vertebrate faunas (e.g., RODDA & FRITTS 1992; RODDA et al. 1997). One road kill was found in the vicinity of Lirung, Salibabu Island. This is the first record of *B. irregularis* for the Talaud Archipelago.

Morphology: One preocular, two postoculars, one loreal; eight supralabials, the fourth to sixth in contact with orbit; ten and eleven infralabials, respectively; 19 scales around body, about 247 ventrals and 115 subcaudals; the vertebrae are slightly enlarged. The specimen shows a narrow pattern of indistinct light and dark grey cross-bands particularly on the anterior half of body as is typical for some *B. irregularis*.

***Cerberus r. rynchops* (Schneider, 1799)**

Material examined: none

Additional material: RMNH 6262, Karakelong, coll. Dr. H. BOSCHMA 14–21 June 1930.

Distribution: This widespread homalopsine snake is known to occur from continental Southeast Asia through the Philippines and Indonesia reaching New Guinea (GYI 1970; ALFARO et al. 2004). DE JONG (1928) reported the species for Karakelong as did BRONGERSMA (1934) based on a specimen (see ‘additional material’) collected in 1930. While DE HAAS (1950) listed only the Talaud Islands in the species account of *C. rynchops*, Salebabu (= Salibabu) Island is mentioned in the distribution appendix.

Taxonomy: GYI (1970) recognized two subspecies: the widely distributed *C. r. rynchops* and *C. r. novaeguineae* from New Guinea. According to DE LANG & VOGEL (2005) the Talaud population belongs to the nominotypic subspecies. ALFARO et al. (2004), however, demonstrated that *C. r. rynchops* is split into four to five phylogenetic lineages (India and Myanmar, Philippines, Greater Sunda Islands and Sulawesi, and the Thai-Malay Peninsula and Gulf of Thailand). Thus, the taxonomic status of the Talaud population remains unclear.

CROCODYLIA**Crocodylidae*****Crocodylus* sp.**

Material examined: none

Taxonomy: In 1997 two unidentified crocodiles were observed on Karakelong Island (J. RILEY, pers. comm. in PLATT & LEE 2000). Although currently the taxonomic status of the Sulawesi populations and hence that of the Talaud Archipelago is still unsolved, it is reasonable to suggest that the widespread *Crocodylus porosus* or another species, *C. mindorensis* from the Philippines, respectively, inhabits the Talaud island group (PLATT & LEE 2000; PLATT et al. 2007).

Ecology: Reportedly, these crocodiles live in mangrove swamps which are threatened by destruction. However, apparently due to religious taboos villagers do not kill crocodiles (J. WARDILL, pers. comm. in PLATT & LEE 2000).

TESTUDINES**Cheloniidae*****Chelonia mydas* (Linnaeus, 1758)**

Material examined: none

Ecology: *Chelonia mydas* is known to have nesting sites on the Talaud Islands (WHITTEN et al. 2002). Although no trade with sea turtles and their products was noticed on Salibabu Island, repeated observations were made in the markets of Manado and elsewhere on North Sulawesi that sea turtles and their eggs were sold for human consumption.

4. DISCUSSION**Species diversity, island endemism and nature conservation**

Some authors have pointed out the depauperate but highly endemic character of the nearby Sangihe and Talaud Archipelagos (e.g., LAZELL 1992; RILEY 2002). This statement partly contradicts the geological assumption that the Talaud block did not emerge above sea level until the Pleistocene (MOORE et al. 1981). Repeated drops in global sea levels during the Pleistocene did probably not connect the Talaud Archipelago with the neighboring Sangihe Islands, from which it is separated by a deep ocean trench, or with any other surrounding landmasses (VORIS 2000). Accordingly, LAZELL (1992) hypothesized that amphibians and reptiles must have colonized Talaud by over-water dispersal. Faunal and floral colonizers of the Talaud Archipelago had presumably less than two million years to succeed or even to evolve endemic lineages. Thus, the degree of endemism of Talaud’s herpetofauna is relatively low (only 4 %). Currently, only *Varanus* sp. seems to be restricted to the island group but the number of Talaud endemics may increase by up to 27 % in the future, when the taxonomic status of some problematic specimens belonging to widespread species or species groups has been clarified (e.g., *Nactus* cf. *pelagicus*, *Cyrtodactylus* cf. *jellesmae*, *Hydrosaurus* sp., *Lamprolepis smaragdina* ssp., *Callulops* cf. *dubius*, and *Typhlops* sp.). Detailed systematic investigations including modern molecular techniques are needed to solve their taxonomic identity.

As expected for small oceanic islands (STERNFELD 1920; BROWN 1957; ADLER et al. 1995; ALLISON 1996; CROMBIE & PREGILL 1999), skinks (next to geckos) are the most diverse reptile group on the Talaud Islands, while amphibians are very rare due to their limited ability to cross salt-water barriers. However, no *Sphenomorphus* skinks were

found during our biodiversity survey on Salibabu Island although this taxonomically difficult and diverse genus is well represented on the adjacent islands of Sulawesi, Halmahera and Mindanao (BROWN & ALCALA 1980; ISKANDAR & NIO 1996; MONK et al. 1997). In addition, flying lizards of the genus *Draco* were not observed during our field work, nor during previous expeditions to Salibabu Island (DE JONG 1928; MCGUIRE et al. 2007). In contrast, LAZELL (1992) predicted the sympatric occurrence of two *Draco* species for Talaud, one of which he assumed to be a giant, based on biogeographic knowledge of the Lesser Antilles *Anolis* lizards. Therefore, future field surveys concentrating on the forested areas of the larger island of Karakelong are needed to verify the presence of *Draco* spp. on the Talaud Islands. The same applies to *Gekko vittatus* and *Bronchocele jubata*, which have been reported from Talaud in the past (see above). Further unrecognized amphibian and reptile species may be anticipated to inhabit the Talaud Archipelago.

As in many Pacific island biotas and beyond, *Boiga irregularis*, *Gehyra mutilata*, and *Hemidactylus frenatus* are most probably non-native, naturalized species of the Talaud Archipelago. Because these reptiles are not utilized by man, they have likely reached this island group via accidental human-mediated transportation. Nevertheless, the ability to "use" boats and ferries for over-water dispersal renders these three species as candidates to cross far distances on natural rafts as well. A determination between accidental human-mediated displacement on the one hand and natural colonization on the other seems virtually impossible.

In any case, the new record of the invasive brown tree snake *B. irregularis* for Talaud may have severe consequences for the native vertebrate fauna of this island group. As was demonstrated by several studies (e.g., SAVIDGE 1987; RODDA & FRITTS 1992; RODDA et al. 1997), this snake species is responsible for the dramatic decline in bird and lizard populations on Guam. This could be particularly fatal for endemic lizard species like the Talaud monitor lizards which have a very restricted distribution range (KOCH et al. subm.). SAVIDGE 1988 and MCCOY et al. (1994) reported from Guam that *B. irregularis* even preys on juveniles of *Varanus indicus*. Therefore, the development of the Talaud population of this invasive snake species deserves special attention in the future.

Deforestation and destruction of natural habitats represent another major threat to the amphibians and reptiles of the Talaud Archipelago as was pointed out by RILEY (2002) for the mammals of this island group. Coconut plantations replace natural vegetation in most areas. Therefore, a wildlife reserve has been established on the larger island of Karakelong to protect endemic faunas (RILEY 1997).

Biogeographic relations and past dispersal routes

Although it may seem premature, some conclusions can be drawn about the biogeographic origin and affinities of the Talaud Islands' herpetofauna based on current distribution patterns of amphibians and reptiles of the Indo-Australian Archipelago. Firstly, several typical Australopapuan species or species groups (viz. *Litoria infrafrenata*, *Candoia paulsoni*, *Nactus cf. pelagicus*, *Eugongylus rufescens*, *Lipinia noctua*, and *Varanus* sp. [aff. *indicus*]), reach their most north-western distributions on the Talaud Islands. These Australopapuan faunal elements probably arrived at this island group via Halmahera and adjacent islands in the northern Moluccas. Some species with Oriental origin, such as *Eutropis multifasciata* and *Eutropis cf. rudis*, have their most easterly distribution on or around the Talaud Islands. Consequently, the Talaud Archipelago's biogeographic position within the Wallacea transition zone is clearly warranted (see COX 2001 for a recent review of the Wallacea region). Interestingly, few widespread Oriental species like *Varanus salvator* did not reach the Talaud Archipelago despite its abundance on Sulawesi and smaller off-shore islands. An explanation for this may be the flow of Pacific water into the Indian Ocean via the Indonesian seas. This throughflow enters the Indonesian Islands in north-eastern to south-western direction between Mindanao and the Talaud group passing the Celebes Sea while another sea current from the Pacific circulates between Talaud and Halmahera (GORDON & FINE 1996, GORDON 2005), thus hampering over-water dispersal on natural rafts.

Secondly, the herpetofauna of Talaud shows clear biogeographic relations to Halmahera in the northern Moluccas and, to a lesser extent, to Sulawesi and to the Philippines. With the northern Moluccas the Talaud Archipelago has 20 amphibian and non-marine reptile species in common, while it shares only 14 amphibians and non-marine reptiles with Sulawesi and the Philippines, respectively (see Tab. 1). With regard to amphibians, two out of three Talaud species also occur on Halmahera and, at least in one case (*Litoria infrafrenata*), farther southeast on New Guinea and adjacent islands. In contrast, no frog species from the Philippines seem to have reached the Talaud Islands. *Limnonectes modestus* which inhabits Sulawesi is also found on the Talaud Islands and some islands of the Moluccas. For the terrestrial reptiles, four species (respectively five when *Gekko vittatus* is included) are exclusively shared by the Talaud Archipelago and the northern Moluccas including areas further southeast. These are *Candoia paulsoni tasmai*, *Nactus cf. pelagicus*, *Eugongylus rufescens*, and *Lipinia noctua*.

Due to their central position in the Molucca Sea, there are no native species exclusively common to the Talaud Is-

Table 1. Distribution records of amphibians and reptiles from the Talaud Islands as compared to the surrounding islands of Sulawesi, Halmahera and the Philippines. Probable non-native, i.e. invasive species of the Talaud Islands are indicated by a hash key (#). New records for the Talaud Island are marked with an exclamation mark (!); new records for Salibabu Island are denoted by an asterisk (*). An "(x)" denotes that different subspecies or closely related taxa of a species complex, respectively, are involved. ¹ indicates that *Nactus* cf. *pelagicus* has only been recorded from Morotai but due to close proximity most probably also occurs on Halmahera. Locality records for surrounding islands are taken from BOETTGER (1895a, b; 1903), BOULENGER (1897), BARBOUR (1912), DE ROOIJ (1915; 1917), DE JONG (1928), TANNER (1950), BROWN & ALCALA (1970), BROWN & ALCALA (1980), BROWN (1991), MONK et al. (1997), HALLERMANN (2005), and ZIEGLER et al. (2007).

Taxon	Locality			
	Sulawesi	Talaud	Halmahera	Philippines
ANURA				
Hylidae (1 sp.)				
<i>Litoria infrafronata</i>		x	x	
Microhylidae (1 sp.)				
<i>Callulops</i> cf. <i>dubius</i>		x!	x	
Ranidae (1 sp.)				
<i>Limnonectes</i> cf. <i>modestus</i>	x	x	(x)	(x)
SAURIA				
Agamidae (3 spp.)				
<i>Bronchocela cristatella</i>	x	x	x	x
<i>Bronchocela jubata</i>	x	?		?
<i>Hydrosaurus</i> sp.	(x)	x*	(x)	(x)
Gekkonidae (5 spp.)				
<i>Cyrtodactylus</i> cf. <i>jellesmae</i>	x	x*	(x)	
<i>Gehyra mutilata</i> #	x	x!	x	x
<i>Gekko vitattus</i>		?	x	
<i>Hemidactylus frenatus</i> #	x	x	x	x
<i>Nactus</i> cf. <i>pelagicus</i>		x!	x ¹	
Scincidae (8 spp.)				
<i>Emoia a. atrocostata</i>	x	x*	x	x
<i>Emoia caeruleocauda</i>	x	x	x	x
<i>Eugongylus rufescens</i>		x	x	
<i>Eutropis m. multicaarinata</i>		x*		x
<i>Eutropis multifasciata</i>	x	x!	x	x
<i>Eutropis</i> cf. <i>rudis</i>	x	x!		x
<i>Lamprolepis smaragdina</i> ssp.	(x)	x	(x)	(x)
<i>Lipinia noctua</i>		x	x	
Varanidae (1 sp.)				
<i>Varanus</i> sp. (aff. <i>indicus</i>)		x	(x)	
SERPENTES				
Typhlopidae (1 sp.)				
<i>Typhlops</i> sp.		x!		(x)
Boidae (1 sp.)				
<i>Candoia paulsoni tasmai</i>	?	x	x	
Pythonidae (1 sp.)				
<i>Python reticulatus</i>	x	x	x	x
Colubridae (2 spp.)				
<i>Boiga irregularis</i> #	x	x!	x	?
<i>Cerberus r. rynchops</i>	x	x	x	x
CROCODYLIA				
Crocodylidae (1 sp.)				
<i>Crocodylus</i> sp.	x	x	x	x
TESTUDINES				
Cheloniidae (1 sp.)				
<i>Chelonia mydas</i>	x	x	x	x

lands and the Philippines and Halmahera, and only one species, *Eutropis cf. rudis*, in common with the Philippines and Sulawesi. However, some widespread non-invasive species like *Cerberus rynchops*, *Python reticulatus*, *Bronchocela cristatella*, *Emoia atrocostata*, *E. caeruleo-cauda*, *Eutropis multifasciata*, and *Lamprolepis smaragdina* are found at all four localities. It seems plausible that such widespread species were exchanged between the Philippines and the Moluccas by using Sulawesi as a stopover rather than the Talaud Islands (but see below). Hence, the Philippines may have been colonized via the Sangihe Island chain or arrived at the Moluccas via the Banggai-Sula Islands finally reaching the Talaud Archipelago in the north. Nevertheless, it remains doubtful whether the Talaud Islands served as natural stepping stones (particularly during periods of lowered Pleistocene sea levels) on the dispersal route between the Philippines and North Sulawesi. INGER (1954) argued that the present distribution of the genus *Oreophryne* Boettger, 1895, which also occurs on Sulawesi and some islands of the Lesser Sundas may account in favor of the Moluccan-Talaud corridor. *Oreophryne*, however, was never recorded from the Talaud Islands. The same applies to the genus *Cornufer* Tschudi, 1838 (currently a synonym of *Platymantis* Günther, 1858), which ranges from the Philippines through the Moluccas to New Guinea and the Solomons, but is not known from Sulawesi. According to INGER (1954), this taxon constitutes more evidence for the Talaud avenue between the Philippines and the Moluccas which also was later identified as major route of faunal dispersal by HOLLOWAY & JARDINE (1968). In either case, the extinction or replacement of former Talaud populations by later invaders may explain their absence from the island group. As noted by WHITTEN et al. (1987) biological evidence for a stepping stone hypothesis between the Philippines and the Moluccas via Talaud is still insubstantial. Only further field work and detailed morphological comparisons of sufficient material together with molecular investigations including individuals from all areas involved could trace the unique history for each single species and the region.

Comparison with other organism groups

Distribution patterns of some other organism groups vary from the herpetological results presented here. VANE-WRIGHT & DE JONG (2003) traditionally included the Talaud Islands as part of the Sulawesi region in their review of Sulawesi butterflies. They predicted that colonization from the Philippines into North Sulawesi happened via Sangihe and Talaud. Likewise, NATUS (2005) in her analysis of endemic centers of Indonesian vertebrates defined the Sulawesi region as the mainland of Sulawesi plus surrounding island groups like Sangihe and Talaud in the

north. Interestingly, our herpetological results contradict the findings in butterflies by VANE-WRIGHT & DE JONG (2003) who eventually concluded that the fauna of the Talaud Archipelago most probably “belongs” to the Mindanao fauna.

With regard to mammals, the Talaud and Sangihe Islands are home to an endemic marsupial, the Talaud bear cuscus (*Ailurops ursinus melanotus*). These populations represent the northernmost subspecies of this Sulawesian phalanger (FEILER 1977; 1990). At the same time, *A. ursinus* is the only example of a non-volant and non-invasive mammal that inhabits both neighboring archipelagos (RILEY 2002). Human translocation could be responsible for the exceptional distribution pattern of this species which is frequently hunted as food. On the other hand, both island groups harbor their own endemics, e.g., *Tarsius sangirensis* on Sangihe and *Melomys caurinus* on Talaud (RILEY 2002), which have their respective closest relatives on North Sulawesi and the northern Moluccas (FLANNERY 1995; MENZIES 1996; SHEKELLE 2003). There is another population of *T. sangirensis* on the nearby Siau Island, which may warrant a separate taxonomic status (BRANDON-JONES et al. 2004). As a result, these mammal taxa confirm the minor faunal similarity between Sangihe and Talaud, and at the same time, supply evidence for their close biogeographic relationships with Sulawesi and New Guinea, respectively.

Consequently, the tradition to incorporate the Talaud Archipelago into the Sulawesi subregion within the transitional zone of Wallacea seems only conditionally justified from a herpetofaunistic point of view. Rather, this island group should be recognized as part of the northern Moluccan subregion with closer zoogeographical links to Halmahera compared with Sulawesi or the Philippines. The transitional character of the herpetofauna of the Talaud Islands composed of both typical Oriental and Australopapuan faunal elements clearly reinforces the justification of the Wallacea region between Southeast Asian and Australopapuan biotas.

Acknowledgements. We would like to thank the Indonesian Institute of Sciences (LIPI) for the permission (2767/SU.3/KS/2005) to conduct research in Indonesia. The kind support of Pak Dedy Darnaedy (Research Center for Biology, LIPI) Pak Mulyadi and Pak Irvan Sidik (both MZB) is acknowledged, too. Further we are grateful to Ibu Mumpuni (MZB) for the permission to examine specimens under her care. In addition, we are greatly indebted to Pak Henry, teacher in Lirung (Salibabu Island), who substantially supported our field work as well as to Sahid Kampi (Tahuna, Sangihe Island) and his brother in Lirung (Salibabu Island) for logistic support. We thank Rainer Günther (Berlin, Germany), Jakob Hallermann (Hamburg, Germany), Maren Gaulke (Munich, Germany), and An-

dreas Schmitz (Geneva, Switzerland) for discussions about the identification of single specimens. Bernhard Huber (ZFMK), Peter Jäger (Naturmuseum Senckenberg, Frankfurt, Germany) and Siegfried Ingrisch (Bad Karlshafen, Germany) kindly provided identifications of the arthropod remains of *Varanus* specimens. Kai Philipp (Baden-Baden, Germany) kindly provided the photograph of a Talaud monitor lizard and Uwe Fritz, Edgar Lehr (both MTDK) and Eulália Gasso-Miracle (RMHN) information about Sulawesi specimens in their collections. We also appreciate the shared information of Jimmy McGuire (Berkeley, USA) about the herpetofauna of Sulawesi. Finally, Jon Riley (Great Britain) and Ruud de Lang (Rotterdam, the Netherlands) kindly made available relevant literature sources about the Talaud Islands. Robert Neal (Brisbane, Australia), Mark Auliya (Selangor, Malaysia), and an anonymous reviewer made many helpful comments on an earlier version of the present paper. The companies M & S Reptilien (VS Weigheim, Germany) and Peter Hoch (Waldkirch, Germany) provided equipment for the expedition. Financial support for the ongoing project about the herpetofaunal diversity, endemism, and biogeography of Sulawesi and adjacent islands was provided by a PhD scholarship (AK) from the Evangelisches Studienwerk e.V. Villigst.

This is publication No. 7 of the co-operation project about the herpetofauna of the Sulawesi region between the herpetological sections of the Zoologisches Forschungsmuseum A. Koenig Bonn (ZFMK), Germany, and the Museum Zoologicum Bogoriense (MZB), Bogor, Indonesia.

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Received: 13.08.2008

Revised: 15.01.2009

Accepted: 20.01.2009

Corresponding editor: R. van den Elzen